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Effect of different irrigation levels on the performance of wheat

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Abstract

An experiment was conducted at the research field of the Department of Agricultural Botany, Patuakhali Science and Technology University, Patuakhali under the Agro-ecological zone-13 (AEZ-13) during the period from November 2012 to February 2013. The aim of the study was to identify the most effective irrigation level for obtaining the better growth and higher yield performance of BARI Gom-25 that are suitable to cultivate under coastal region of Patuakhali, Bangladesh. So, the present study was consists of five irrigations levels including control *viz.* control or no irrigation (T_0), one irrigation at 25 DAS (T_1), two irrigations at 25 and 40 DAS (T_2), three irrigations at 25, 40 and 55 DAS (T_3) and four irrigations at 25, 40, 55 and 70 DAS (T_4). The seeds of BARI Gom-25 were collected from the BARI, Joydebpur, Gazipur on 22 November, 2012. The experiment was laid out in completely randomized block design (RCBD) with four replications and analysis was done by the MSTAT-C package program where means were separated by DMRT at 5% level of probability. Data were recorded on various growth and yield attributing traits. The plot size was 5 m^2 (2.5 × 2.0 m) where row to row and seed to seed distances were 20 and 10 cm respectively. Data were collected on various morpho-physiological growth, yield and yield attributing traits. Results obtained from the present study, whole characters of the study were significant at 5% by the moisture (irrigation) levels where three irrigations given at 25, 40 and 55 DAS had most effective than that of other moisture levels and no irrigation. From the results investigation, it was found that the tallest plant (76.86 cm), maximum requiring days to anthesis (61.00 days), maturity (109.0 days) and maximum number of effective tillers (5.00 $hill^{-1}$),the highest grain growth (3.11g at 36 DAA) and grains (44.00 $spike^{-1}$) were obtained with three irrigation (T_3) levels. Similarly, T_3 further showed the greater performance on spike length (17.28 cm), 1000-seed weight (50.16 g), grain (4.16 t ha^{-1}), straw (5.89 t ha^{-1}) and biological yield (10.05 t ha^{-1}) as well as the higher harvest index (41.39%). Investigated above whole characters were produced lower performances under no moisture (irrigation) treatments. These results indicated that irrigation at three times (T_3) would be most advantageous irrigation levels for wheat production under the studied non saline ecosystem of coastal region.

Key words: Wheat, different irrigation level, growth, yield

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Introduction

Wheat (*Triticum aestivum L.*) is one of the leading cereals in the world. It belongs to the family Gramineae and it is the world's most widely cultivated cereal crop which ranks first followed by rice. It is preferable than rice for its higher seed protein content. It ranks first both in acreage and production among the grain crops of the world (FAO, 2008). BARI (2006) also reported that wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals. Among the factors responsible for low grain yield of wheat, different factors are involved such as fluctuation of temperature lack of irrigation water and plant nutrient, weed competition, insect attack, disease infection etc. are the most important. About 30% of wheat production is lost due to lack of irrigation water and 40% yield loss due to lack of nutrient supply and metal contents in soil as well as their availabilities, pollution status of other environmental parameters in the country (Uddin *et al.*, 2016; Sarker *et al.*, 2018; Islam *et al*, 2016). However, enough irrigation water and nutrient supply can increase yield up to 70% in our country (Ahmed, 2006, Uddin *et al.*, 2016). Irrigation frequency has a significant influence on the growth and yield of wheat. With the increase of irrigation frequencies the grain yield of wheat can be increased (Khajanij and Swivedi, 2007). On the other hand frequencies of pesticides application in a crop also affected the quality of crop values based on economically as well as health aspects concerning food insecurity (Rahman *et al.*, 2016; Islam *et al.*, 2015a,b,c). Proper time of irrigation especially in crown root initiation stage is very important for successful growth of wheat and it has a great impact on higher grain yield (Randhawa *et al*., 2004).

In Bangladesh, the rainfall during Rabi season in characteristically scanty and uncertain. As such, wheat gives poor yield under non-irrigated (rainfed) condition. Moreover, irrigation facilities are not so extensive to ensure abundant irrigation water throughout the country. So, irrigation water with judicious application at the peak period of growth stages is one of the approaches of irrigation scheduling in wheat cultivation and it may provide optimum yield of this crop.

Materials and Methods

The experiment was conducted at the farm of Patuakhali Science and Technology University, Dumki, Patuakhali during the period of November 2012 to February 2013 to observe the effect of irrigation frequencies at different days after interval regarding to growth development and yield performance of wheat variety cv. BARI Gom 25 (Tista). The soil of the experimental land belongs to the Barisal series of non- calcareous clay soil but they become more silty in the east and usually have a buried peat layer in the west under the Ganges Tidal Floodplain (AEZ-13). Wheat variety Tista (BARI Gom 25) was used as plant material. It was developed by BARI which was released in 2010. It is also suitable for optimum and late sown conditions and it is suitable to cultivate in southern region, it is moderately tolerant to salinity up to 10 dS m^{-1}. The experiment was undertaken to study the effects of five different irrigation treatments including control on the growth and yield of wheat. These five treatments were as follows-T_0: No irrigation,T_1: Irrigation at 25 DAS,T_2: Two irrigations at CRI 25 and 40 DAS .T_3: Three irrigations at 25, 40 and 55 DAS andT_4: Four irrigations at 25, 40, 55 and 70 DAS. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications where each replication was consisted of five unit plots as a block. There were 20 plots for experiment having the size of 2.5 m × 2 m and two seeds per hill were sown within the plots. The distance between the plot and the block were 50 cm and 100 cm, respectively. The fertilizers N, P, K and S in the form of Urea, TSP, MOP and Gypsum respectively were applied. The entire amount of TSP (180kg/ha), MOP(50kg/ha)and Gypsum(120kg/ha) , 2/3rd of urea were applied during the final land preparation. Rest of urea was top dressed after first irrigation. The height of plant was recorded in centimeter (cm) at harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant. Leaf area index was measured by dividing leaf area plant^{-1} with surface area (cm^2) covered by the plant.

$$\text{LAI} = \frac{\text{Leaf area per plant } (cm^{-2})}{\text{Soil surface area covered by each plant } (cm^{-2})}$$

Days to 50% and 100% anthesis was recorded by calculating the number of days from sowing to 50% and 100% spikes completed their anthesis. Days to

50% and 100% maturity was recorded by calculating the number of days from sowing to 50% and 100% spikes becomes brown color.The total number of effective tiller hill^{-1} was counted as the number of panicle bearing hill plant^{-1}. Data on effective tillers hill^{-1} were counted from 10 selected hills at harvest and average value was recorded.The total number of grains spike-1 was counted as the number of spikelets from 10 randomly selected spikes from each plot and average value was recorded.Spike length was measured from the basal node of the rachis to the apex of each spike from the randomly selected ten spikes from the 10 hills and their average length was recorded and converted in to cm. One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

Before harvest, some spikes were tagged at different days of anthesis and harvests were taken at an interval of 4 days. Eleven harvests were taken during the period of experimentation. Eight spikes of main tillers were cut (per replication = 2 spikes) at each harvest and they were dried in an oven at 85°C for 24 hours. After drying, spike weights were recorded. Grain weight of wheat obtained from the isolated harvested area of each plot, after threshing, cleaning and sun drying for 2-3 days the data was recorded into kg plot^{-1} on 12% moisture basis. Thereafter the obtained data was used to calculate yield (ton ha^{-1}). After harvesting and threshing, the grain less straw was dried in sun for 2–3 days. Finally, straw weights were taken on individual plot basis at moisture content of 12% and then converted into t ha^{-1}. Biological yield is the sum of grain and straw yield which was recorded into kg plot^{-1} and finally converted into t ha^{-1}. The biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield. Harvest index is the ratio of economic yield to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yiel d}}{\text{Biological yield}} \times 100$$

***Statistical analysis*:** The data obtained for different characters were statistically analyzed to observe the significant difference among the irrigation frequencies on the growth and development of wheat. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Response of irrigation on morpho-physiological characters of wheat

***Days to anthesis*:** Analysis of variance of data regarding days to anthesis was significantly influenced among the irrigation treatments (Table 1). Among the irrigation treatments, three irrigation treatment required the maximum time for anthesis (61.00 days) comparatively than that of other treatments while all the irrigation treatments requiring the maximum time for anthesis than control. As a result, days to anthesis were minimum (53.00 days) under without or no irrigation. Maximum time required for anthesis formed significantly the more filled grain of wheat while early anthesis did not cover full vegetative stage which produced immature or unfilled seeds and decreased the final yield.

Days to maturity: A significant variation was observed due to the effect of various irrigation levels at different time during study (Table 1). The maximum time for maturity (109.00 days) was required under four irrigation treatment while another all irrigation treatments were found to be statistically different for days to maturity at 5% level. On the other hand, minimum days were needed for maturity (91.00 days) under no irrigation treatment. More mature plant produced significantly the more filled grain and mature straw which ultimately maximizing the grain and straw yield. The present results were agreed to the findings of Ngwako and Mashiqa (2013) who reported that the irrigation significantly affected days to maturity. Similarly, Onyibe (2005) reported that increase in irrigation regime however increased days to maturity. Kang *et al*. (2005) also reported the similar findings.

Number of effective tillers hill^{-1}: Number of effective tillers hill^{-1} was significantly affected by the effect of various levels of irrigation in this study (Table 1).

Table 1. Effect of treatments on days to anthesis, days to maturity and number of effective tillers hill^{-1}

Treatments	Days to anthesis (days)	Days to maturity	Number of effective tillers hill^{-1}
T_0	53.00^{e}	91.00^{e}	3.60^{d}
T_1	55.00^{d}	97.00^{d}	3.07^{e}
T_2	57.00^{c}	102.0^{c}	4.25^{c}
T_3	61.00^{a}	105.0^{b}	5.00^{a}
T_4	59.00^{b}	109.0^{a}	4.73^{b}
Significance level	**	**	**
LSD	**0.109**	**1.02**	**0.048**
CV	**1.25**	**0.66**	**0.68**

**= Significant at 5% level of probability; T_0: No irrigation; T_1: Irrigation at 25 DAS; T_2: Two irrigations at CRI 25 and 40 DAS; T_3: Three irrigations at 25, 40 and 55 DAS; T_4: Four irrigations at 25, 40, 55 and 70 DAS.

The maximum number of effective tillers hill^{-1} (5.00) was obtained under three irrigation treatment whereas it was statistically differed from other irrigation and no irrigation. In contrast, no or without irrigation treatment observed the minimum number of effective tillers hill^{-1} (3.60). The variation in tillers production hill^{-1} was found due to the variation in irrigation level and time incase of different time of irrigation affected on soil and happened the variation in moisture and nutrient supply to the plant. Similar study were also obtained by Ali and Amin (2007) who reported that significant effects was observed on number of effective tillers hill^{-1} where two irrigations were more effective.

Performance of BARI Gom-25 as influenced by irrigation in respect of yield attributing characters

***Length of spike*:** Length of spike at harvest was significantly influenced by different irrigation treatments (Figure 1). From the Figure 1, it was appeared that the longest spike at harvest (17.28 cm) was obtained with three irrigations which were not significantly different at 5% level with the result obtained from both two and four irrigations (16.76 and 16.95 cm, respectively).

On the other hand, the shortest spike at harvest (14.64 cm) was shown by no irrigation. This was similar to that of Alsohaibani (2007). Similarly, Khokhar *et al*. (2010) reported that application of five irrigations at different wheat growth stages resulted in higher spike length.

***Number of grains spike^{-1}*:** Number of grains spike^{-1} at harvest was significantly influenced by different irrigation treatments (Table 2). It was observed that the highest number of grains spike^{-1} at harvest (44.00) was obtained with three irrigations which were followed by both two and four irrigations (41.95 and 42.55) where two and four irrigations treatment were statistically identical at 5%. On the other hand, the lowest number of grains spike^{-1} at harvest (33.88) was shown by no irrigation. It was also observed that two or four irrigations showed intermediate results compared to all other treatments. This result is in accord with that of Ngwako and Mashiqa (2013) who found that irrigation throughout the growth stages recorded the more gains spike^{-1}. Similar observation was also found by Mubeen *et al*. (2013); and many scientists of Bangladesh and abroad.

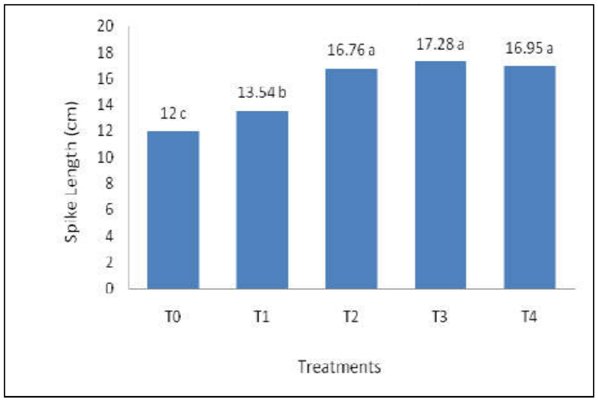

Figure 1. Effect of treatments on spike length

T_0: No irrigation; T_1: Irrigation at 25 DAS; T_2: Two irrigations at CRI 25 and 40 DAS; T_3: Three irrigations at 25, 40 and 55 DAS; T_4: Four irrigations at 25, 40, 55 and 70 DAS.

Weight of 1000 seeds**:** Weight of 1000 seeds was significantly influenced by different irrigation treatments (Table 2). From the Table 2, it was appeared that the highest 1000 seed weight (50.16 g) was obtained with three irrigations which were not significantly different at 5% level with the result obtained from both two and four irrigations (47.96 and 49.62 g, respectively). On the other hand, the lowest 1000 seed weight (38.00 g) was shown by no irrigation. It was also observed that two or four irrigation showed intermediate results compared to all other treatments. The result is in conformity with that of Ali *et al*. (2012a,b) where they found that the full irrigation (T_4, T_5) treatments significantly affected yield and yield components. Taipodia and Singh (2013) also reported that 1000 grain weight was significantly affected by different irrigation levels where 6 irrigations obtained the higher weight of 1000 - seed.

Grain yield**:** A significant variation was also found due to the effect of various irrigation treatments at different times during study (Table 2). Among the irrigation treatments, it was observed that the highest grain yield (4.16 t ha^{-1}) was obtained with three irrigations which was followed by both two and four irrigations (3.59 and 3.86 t ha^{-1}) where two and four irrigations treatment were produced statistically identical grain yield at 5%. On the other hand, the lowest grain yield (2.86 t ha^{-1}) was shown by no irrigation. It was also observed that two or four irrigations showed intermediate results compared to all other treatments. This result is in accord with that of Ngwako and Mashiqa (2013) who found that irrigation throughout the growth stages affect on grain yield. Similarly, Mubeen *et al*. (2013) also reported that irrigation at tillering, stem elongation stage, booting and grain filling stage recorded the higher yield of wheat.

Straw yield**:** Effect of different irrigation treatment at different times during study was significant in respect of straw yield (Table 3). This result observed that the highest straw yield (5.89 t ha^{-1}) was obtained with three irrigations which were followed by both two and four irrigations (5.51 and 5.47 t ha^{-1}) where straw production were statistically identical between two and four irrigations treatment at 5%. On the other hand, the lowest yield of straw (4.74 t ha^{-1}) was shown by no irrigation. It was also observed that two or four irrigations showed intermediate results compared to all other treatments. The result of the present study is in agreement with Qi Wang *et al*. (2012) who also found significant irrigation effect on straw yield. Similarly, Zeidan *et al*. (2009), and many other researchers of Bangladesh and abroad.

Biological yield**:** Analysis of variances (mean squire) value was found to be the Appendix VI, indicated significant difference regarding to biological yield (Table 3). From the Table 3, it was found that the highest biological yield (10.05t ha^{-1}) was obtained with three irrigations given at 25, 40 and 55 DAS which was statistically differed from other irrigation treatments. On the other hand, the lowest biological yield (7.60 t ha^{-1}) was shown by no irrigation. It was also observed that two or four irrigations showed intermediate results compared to all other treatments. The results of the present study are in agreement with Taipodia and Singh (2013); Ghanbari-Malidarreh, 2010 found significant variation among the irrigation treatments.

Table 2. Effect of treatments on number of grains spike^{-1}, weight of 1000-seed and grain yield

Treatments	Number of grains spike^{-1}	Weight of 1000-seed (g)	Grain yield (t ha^{-1})
T_0	33.88 d	38.00 d	2.860 e
T_1	37.38 c	44.40 c	3.080 d
T_2	41.95 b	47.96 b	3.590 c
T_3	44.00 a	50.16 a	4.160 a
T_4	42.55 b	49.62 a	3.860 b
Significance level	**	**	**
LSD	**0.838**	**1.237**	**0.0844**
CV	**2.49**	**1.78**	**1.91**

**= Significant at 5% level of probability; T_0: No irrigation; T_1: Irrigation at 25 DAS; T_2: Two irrigations at CRI 25 and 40 DAS; T_3: Three irrigations at 25, 40 and 55 DAS; T_4: Four irrigations at 25, 40, 55 and 70 DAS

Table 3. Effect of treatments on straw yield, biological yield and harvest index

Treatments	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_0	4.740 d	7.600 d	37.63 c
T_1	5.080 c	8.160 c	37.75 c
T_2	5.510 b	9.100 b	39.45 b
T_3	5.890 a	10.05 a	41.39 a
T_4	5.470 b	9.330 b	41.37 a
Significance level	**	**	**
LSD	**0.137**	**0.433**	**0.576**
CV	**1.71**	**3.17**	**0.95**

**= Significant at 5% level of probability; T_0: No irrigation; T_1: Irrigation at 25 DAS; T_2: Two irrigations at CRI 25 and 40 DAS; T_3: Three irrigations at 25, 40 and 55 DAS; T_4: Four irrigations at 25, 40, 55 and 70 DAS

***Harvest index*:** Harvest index was significantly influenced by different irrigation treatments in the present study (Table 3). It was observed that the highest harvest index (41.39%) was obtained with three irrigation irrigations while statistically similar harvest index (41.37%) was found with four irrigation treatments. On the other hand, the lowest harvest index (37.63%) was shown by no irrigation. It was also observed that both three and four irrigations produced maximum HI than that of other irrigation and without irrigation treatments while two irrigation treatments showed intermediate harvest index (39.45%) compared to all other treatments. This result is in accord with that of Taipodia and Singh (2013) who found that harvest index was significantly influenced by irrigation.

Conclusion

Irrigation treatments was significantly influenced at 5% level of probability among the studied morpho-physiological growth, yield and yield contributing characters where three irrigations had more significant than that of other irrigation treatments and no irrigation. As a result, three irrigations (T_3) recorded significantly the tallest plant (76.86 cm) and maximum requiring days to anthesis (54.80 days) while four irrigations (T_4) obtained the statistically similar height of plant (73.76 cm). Similarly, maximum number of effective tillers (5.00 hill^{-1}) and grains (44.00 spike^{-1}) were also obtained by three irrigation (T_3) treatments. The highest grain growth was obtained at T_3 (3.11 g at 36 DAA), T_4 continued grain growth till 44 DAA but grain growth was decreased than T_3. T_2 and T_1 completed their grain growth at 36 DAA which were less than T_4. Longest spike (17.28 cm) and higher weight of 1000-seed (50.16 g) were also found with three irrigation (T_3) treatment while both two and four irrigation treatment (T_2 and T_4) showed the statistically identical spike length (16.76 and 16.95 cm, respectively) and 1000-seed weight (47.96 and 49.62 g respectively) . Among other studied characters, grain, straw and biological yield and harvest index had also higher (4.16, 5.89 and 10.05 t ha^{-1} and 41.39%, respectively) with three irrigation treatments (T_3) where four irrigation treatments (T_4) showed the statistically identical harvest index as 41.39% and 41.37% respectively. Among the studied morphological and yield attributing characters, the lowest result were obtained by no irrigation such as shortest plant (48.57 cm), lowest LAI (2.50), minimum days to anthesis and maturity (53.00 and 91.00 days respectively), minimum effective tillers (3.60 hill^{-1}), minimum grains (35.38 spike^{-1}), shortest spike (12.00 cm), lowest weight of 1000-seed (38.00 g), lowest yield of grain, straw and biological (2.86, 4.74 and 7.60 t ha^{-1}, respectively) and lowest harvest index (37.63%) were obtained with no irrigation treatments (T_0).

From the above result investigation it is clear that irrigation level and time influenced the whole morphological, growth and yield attributing traits of BARI Gom-25 where three irrigation (T_3) treatments perform better over other irrigation treatments. However somehow it was statistically identical and followed by four irrigations (T_4) except grain filling duration, 1000 seed weight and grain yield. So, irrigation at three times (T_3) would be most advantageous irrigation levels for wheat production under the studied region (AEZ-13). However, further study is needed including more irrigation with least day's interval to optimize irrigation level for ensuring the higher yield.

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